**Chemical Reactions Experiment**

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| **Ministry Expectations:** |
| **Big Ideas:**   * Chemicals react in predictable ways |
| **Overall Expectation:**  **C2.** Investigate different types of chemical reactions  **C3.** Demonstrate an understanding of the different types of chemical reactions. |
| **Specific Expectations:**  **C2.2** write balanced chemical equations to represent synthesis, decomposition, single displacement, double displacement, and combustion reactions using the IUPAC nomenclature system [PR, AI, C]  **C2.3** investigate synthesis, decomposition, single displacement, and double displacement reactions, by testing the products of each reaction (e.g. , test for products such as gases, the presence of an acid, or the presence of a base)  **C2.4** predict the products of different types of synthesis and decomposition reactions (e.g. synthesis reactions in which simple compounds are formed; synthesis reactions of metallic or non-metallic oxides with water; decomposition reactions in which a chemical compound is separated into several compounds) [AI]  **C3.1** identify various types of chemical reactions, including synthesis, decomposition, single displacement, double displacement and combustion |

**Teacher’s Knowledge:**

In the unit students will be studying chemical reactions and are required to learn the six main types of reactions which include synthesis, decomposition, single displacement, double displacement and the two types of combustion reactions. The unit relies on students understanding and predicting these chemical reactions, however, this lab will help them investigate the reactions and identify them. Through experiential learning students will be able to apply the concepts they learned in class to predict the products of the chemical reactions. Therefore, this lab will benefit students since they will have the opportunity to visualize chemical reactions and gain a deeper understanding of how the chemicals react and behave under certain conditions.

Students must be able to write chemical equations. Recall that three factors must be satisfied in writing formula equations: a) the equation must represent the facts, b) the equation must include the correct symbols and formulas of all elements and compounds used as reactants and formed as products, and c) the law of conservation of atoms must be satisfied. In synthesis reactions, two or more substances combine to form a more complex compound. In decomposition reactions (the opposite of synthesis), a complex compound breaks down to form two or more simpler substances. In single displacement reactions, one element is displaced from its compound by a more active element. In double displacement reactions, ions in solution combine to form a product that leaves the reaction environment as a solid (precipitate), an insoluble gas, or as a new molecular species (usually water).

The pre-lab questions are essential for student learning. They scaffold the learning of the students so that they are thinking about the four different types of reactions. Also by mentioning the different tests for gases it allows students to think about the different gasses that are possibly created. The pre-lab gives students the information they need to synthesize during the lab. STSE connections are made in the discussion questions, as real life applications are discussed.

This lab demonstrates four types of reactions: synthesis, decomposition, single displacement and double displacement. Please read safety section with highlighted dangers and attached MSDS.

1. Synthesis reaction is shown via the burning of Magnesium. Heating of magnesium allows oxygen to combine with the Mg to form a metal oxide. The students can also measure the magnesium oxide. Previous knowledge applicable is the law of conservation of mass. Students can measure the products before starting the lab and collect all of the reactants to show that oxygen is combined with magnesium.

2Mg(s) +O2(g) 🡺 2MgO(s)

1. Decomposition is shown via heating of potassium permanganate. When potassium permanganate is heated it decomposes and oxygen gas is liberated. After potassium permanganate is heated take off the Bunsen burner and then test for Oxygen. Oxygen gas is tested via a glowing splint, which will flame upon entry to the tube. A lit splint will not show any change. Also, students can be told that MnO­2 ­forms a black solid as a hint to students. It is likely that students will not be able to determine the reaction on their own, so research can be done to determine the exact chemical reaction. Students should avoid contact with potassium permanganate as it stains the skin.  
   2 KMnO4(s)🡺 K2MnO4(s) + MnO2(s) + O2(g)
2. Single Displacement occurs when Silver Nitrate and Copper react. The silver ions in solution displace the copper on the wire slowly. It is important to let the wire sit in solution for a few minutes to see the full reaction. The longer that the reaction is left, the bluer the solution appears which are the copper ions.

2AgNO3(aq) + Cu(s) 🡺 Cu(NO3)2(aq)+ 2Ag(s)

Single Displacement occurs when Hydrochloric acid and Zinc react. It is important to put a rubber stopper on the test tube. Without a rubber stopper enough hydrogen gas cannot be collected for a positive splint test giving you a false negative.

Zn + 2 HCl 🡺 ZnCl2 + H2

1. Double Displacement occurs when lead nitrate and potassium iodide react. Look at safety notes on chemicals they are toxic. Please note that lead iodide is acutely orally toxic. Please ensure that all waste is disposed of in the INORGANIC WASTE as the chemicals are toxic to aquatic life. The students can use the solubility series to predict which product is a precipitate. PLEASE NOTE not all schools have lead nitrate, if so, please omit this reaction.

Pb(NO3)2(aq) + 2KI(aq) → PbI2(s) + 2KNO3(aq)

Double Displacement occurs when silver nitrate reacts with sodium chloride. Silver nitrate is toxic. The products of the reaction are irritants. Waste should be placed in Inorganic waste. The students can use the solubility series to predict which product is a precipitate.

AgNO3(aq) + NaCl(aq) 🡺 NaNO3(aq)+ AgCl(s)

**Assessment:**

AaL – As the lab is preformed, a participation check can be done to ensure that students are contributing to their groups.

AfL- The lab has marks allotted for pre-lab. This is to ensure that the lab is read in entirety before students attempt to perform the experiments. The pre-lab should be checked by the teacher to ensure that the students have the necessary knowledge to commence with the experiment.

AoL- The lab has marks allotted for observations and discussion questions. These questions are designed to ensure that the students are making the connections between theory and practical.

The lab is a total of 50 marks with marks distributed so that the pre-lab and observation chart together are weighted similarly to the discussion questions. This is because the preparation and execution of the lab are equally important as the theory behind the lab. Since we feel that this lab is focused on the types of chemical reactions 13 of the marks are dedicated to descriping the type of reaction each reaction and the chemical formulas.

**Safety:**

Magnesium Ribbon:

<http://www.sciencelab.com/msds.php?msdsId=9924535>

-highly flammable, moisture sensitive, dangerous when wet

Silver nitrate:

http://www.sciencelab.com/msds.php?msdsId=9927411

-corrosive, toxic and hazardous if it comes into contact with the eyes or if it is ingested

-any extra silver nitrate should be placed into the waste disposal container.

Copper nitrate

<http://sciencekit.com/images/art/Copper_II_Nitrate_220.00.pdf>

-strong oxidizing agent and is toxic if ingested & dispose in waste disposal container.

Potassium Permanganate:

http://www.sciencelab.com/msds.php?msdsId=9927406

-avoid contact with skin

Lead Nitrate:

<http://avogadro.chem.iastate.edu/MSDS/Pb%28NO3%292.htm>

-strong oxidizer, avoid contact with reducing agents

-toxic to aquatic life, do NOT pour down drain

Lead Iodide:

http://www.sciencelab.com/msds.php?msdsId=9924472

-acutely toxic when ingested orally, attacks human organs

-toxic to aquatic life

Hydrochloric Acid

<http://fscimage.fishersci.com/msds/95544.htm>

- May cause eye, skin, and respiratory tract irritation.

-Corrosive to metal

Zinc

<http://www.sciencelab.com/msds.php?msdsId=9925476>

-irritant if comes in contact with skin

Sodium Chloride

<http://www.sciencelab.com/msds.php?msdsId=9927593>

Silver Chloride

<http://www.sciencelab.com/msds.php?msdsId=9927255>

-irritant if comes in contact with skin, wash with soap if contact occurs

Sodium Nitrate:

<http://www.sciencelab.com/msds.php?msdsId=9927271>

-irritant if comes in contact with skin, wash with soap if contact occurs

**Lab Preparation:**

1. Cut magnesium ribbon into pieces for students approximately 4 cm in length.
2. Cut or break off pieces of copper wire approximately 4 cm in length.
3. Silver nitrate can be stored in an 8% stock solution and then diluted 1 in 8 for a 1% solution. Concentrated silver nitrate is very harmful if inhaled therefore work under a fume hood.
4. Potassium iodide can be stored as a 1M stock solution; this can be diluted to a 0.05M solution or 1 in 20 dilution.
5. Lead (II) nitrate can be stored as a stock solution; this can be diluted to a 1% solution. If available, put 1% lead (II) nitrate into dropper bottles.
6. Hydrochloric acid is usually stored as a 20N concentrated solution which requires a 1 in 20 dilution for 1M HCl.
7. Sodium Chloride can be stored in a 5M concentrated solution. If NaCl crystallizes then heat until crystals dissolve. Dilute 1 in 5 for 1M NaCl.
8. Each group of students will require the following equipment 5 test tubes, 1 test tube holder, 1 tong, 1 tile, 1 Bunsen burner, 1 forceps, 1 granulated cylinder, 1 rubber stopper, 3 safety goggles so that the class requires:
   * 40 test tubes
   * 8 test tube holder
   * 8 test tube rack
   * 8 tongs
   * 8 tiles
   * 8 Bunsen burners
   * 8 forceps
   * 8 rubber stoppers
   * 8 10mL granulated cylinders
   * 24 safety goggles
9. Each group of students require the following chemicals 4cm of copper wire, 10mL of silver nitrate, 2g of potassium permanganate, 4cm of magnesium ribbon, 5mL of potassium iodide, 10 mL dropper bottle of lead (II) nitrate, 5mL sodium chloride, 1 piece zinc, 5mL of hydrochloric acid such that the class requires:

* 32 cm copper wire
* 80 ml 1% silver nitrate
* 16 g potassium permanganate
* 32 cm magnesium ribbon
* 40 mL1M potassium iodide
* 8 bottles of 10 mL 1M lead (II) nitrate ( approximately 80mL of lead (II) nitrate)
* 8 pieces of zinc
* 40 mL 1M HCl

**Lab Set-up:**

-for 24 students there can be groups varying from 2 to 4 depending on the scarcity of the resources and classroom management

-an ideal set-up is 8 groups of 3, 2 members can perform the experiment while one record the results and then rotate giving everyone a chance to do all tasks

-a demonstration regarding the setup of each lab reaction should be given to the class before they begin to collect equipment and chemicals

-safety precautions should be outlined before any student begins lab (see **Safety** section)

-all chemicals, equipment and waste should be placed at the front of the room so that the teacher can distribute and monitor the distribution and collection of chemicals

Gas

Sink

Group 1

Group 8

Waste

Chemicals

Group 2

Group 3

Group 4

Group 5

Group 6

Group 7

Teacher’s Bench

Equipment

Student Desks

**Demonstrated Set-up:**

Show students to hold test tube away from themselves

Remind students to place MgO on tile

Wall

**Pre-lab Questions:**

1. Write a general equation to describe (4 marks)
   1. Synthesis

A + B 🡪 AB

* 1. Decomposition

AB 🡪 A + B

* 1. Single displacement

AB + C🡪 AC + B

* 1. Double Displacement

AB + CD 🡪 AC + BD

1. Read the following lab and create a data chart to record your data. The table must include the properties of the reactants and products, observations made during the reaction, the splint result and the type of reaction. (1 mark)

See below

1. a) Describe what gases can be tested using the splint test. (4 marks)

Oxygen, hydrogen and carbon dioxide can be tested by using the splint test.

1. What are the outcomes for these gases using the splint test?

Oxygen-glowing splint lights

Hydrogen – lit splint extinguishes with “pop” sound

Carbon dioxide – lit split extinguishes with no sound

1. Read the following lab and list any chemical that are dangerous and answer the following questions: (4 marks)
   1. List the chemicals are the most dangerous?

All chemicals are dangerous if ingested. Any of chemicals listed is acceptable.

* 1. Is there any special disposal of the products of the following reactions?

Nitrates are harmful to the environment and should be placed in inorganic waste. Lead compounds are toxic and should be placed in inorganic waste.

* 1. Can you mix two chemicals in a graduated cylinder?

You cannot, it is unsafe as graduated cylinders are not designed to handle corrosive chemicals or heat.

* 1. What safety equipment should be worn at all times?

Safety goggles.

**Chart Table:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Reaction** | **Properties of Reactants**  **(Before Reaction )** | **Observations During Reaction** | **Properties of Products**  **(After Reaction)** | **Splint Test Result** | **Type of Reaction** |
| **1** | **Cu(s) – brown metal wire, malleable**  **AgNO3(aq) – clear liquid** | **Wire turns grey in colour, liquid begins to turn a light blue colour** | **Ag(s)- grey precipitate forms**  **Cu(NO3)2(aq) – copper ions turn solution blue** |  | **Single Displacement** |
| **2** | **KMnO4(s) – purple crystalline solid** | **Solid begins to turn and gas is formed** | **MnO2(s) – black solid**  **K2MnO4(s)- greenish solid**  **O2(g) – clear gas** | **O2 (g) because splint lights up** | **Decomposition** |
| **3** | **Mg(s) – soft metallic solid, ductile** | **Combusts and turns white in colour** | **MgO(s) – white solid** |  | **Synthesis** |
| **4** | **KI(aq) – clear liquid**  **Pb(NO3)2(aq) – clear liquid** | **Yellow precipitate forms** | **PbI(s) – yellow precipitate**  **KNO3(aq) – clear liquid** |  | **Double Displacement** |
| **5** | **NaCl (aq) – clear liquid**  **AgNO3(aq) – clear liquid** | **White precipitate forms** | **AgCl(s) – white precipitate**  **NaNO3 (aq)- clear liquid** |  | **Double Displacement** |
| **6** | **Zn (s)-metallic, solid**  **HCl(aq) –clear liquid, acidic** | **Bubbles formed, zinc may change in colour sightly** | **ZnCl(aq) –clear liquid**  **H2 (g) -gas** | **H2 (g) – since a lit splint is extinguished** | **Single Displacement** |

**Discussion Questions:**

1. Write a balanced equation for all of the reactions preformed and name what type of chemical reaction occurred. (18 marks)

For each 6 reaction there is one mark for the equation, one mark for a balanced reaction and one mark for the name of the type of reaction (6x3) See Teacher’s knowledge section.

1. What element or compound is responsible for the colour of the solution after Reaction 1 has occurred? (1 mark)

Copper gave the solution a blue colour.

1. Name a product of Reaction 2 and describe how it was identified? (1 marks)

The product was O2, it was identified using a glowing splint.

1. Magnesium ribbon is sometimes used as a fire starter when camping. What would be produced if it rained after the magnesium was burned? What type of chemical reaction is this? (1 marks)

MgO +H2O🡺 Mg(OH)2

Synthesis reaction

1. The precipitate formed in Reaction 4 is often used in paint; suggest a possible method that one could use to separate the products. (1 mark)

The products of Reaction 4 are a liquid and a yellow precipitate which could be separated using filtration or centrifugation.

1. What would happen if you didn’t clean the graduated cylinder while measuring the two reactants in reaction 5? (1 mark)

When measuring the second liquid, the white precipice would form immediately.

1. Why is it not a good idea to clean your metal countertops with an acid such as hydrochloric acid? (1 mark)

Acid reacts with metals to produce hydrogen gas and metal chlorides. This would result in the corrosion of the countertops.

**Investigating Chemical Reactions**

**Introduction:**

Chemical reactions are used in our everyday lives, some examples being when rust forms on a car, manufacturing paper, production of metals and baking a cake. During this lab you will carry out a variety of qualitative reactions. You will need to review the indicators of a chemical reactions, nomenclature and naming of chemical compounds. **Make observations before, during and after each reaction**. Some of the reactions will require you to test for gases. Recall that hydrogen “pops” with blazing splint and oxygen causes a glowing splint to re-ignite whereas carbon dioxide extinguishes a lit split with no sound.

**Purpose:**

To investigate, predict and classify chemical reactions into one of the four following categories synthesis, decomposition, single decomposition and double decomposition.

**Pre-lab Questions: (13 Marks)**

1. Write a general equation to describe (4 marks)
   1. Synthesis
   2. Decomposition
   3. Single displacement
   4. Double Displacement
2. Read the following lab and create a data chart on a separate sheet of paper to record your data. The table must include the properties of the reactants and products, observations made during the reaction, the splint result and the type of reaction. (1 mark)
3. Describe what gases can be tested using the splint test. (4 marks)
   1. What are the outcomes for these gases using the splint test?
4. Read the following lab and list any chemical that are dangerous and answer the following questions: (4 marks)
   1. List the chemicals are the most dangerous?

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* 1. Is there any special disposal of the products of the following reactions?

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* 1. Can you mix two chemicals in a graduated cylinder?

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* 1. What safety equipment should be worn at all times?

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**Reaction 1:**

**Materials:**

* Safety goggles
* Copper wire
* 10 mL graduated cylinder
* 5 mL of 1% Silver nitrate (AgNO3)
* Test tube
* Test tube rack
* Pencil

**SafetyPrecautions:**

* Silver nitrate is corrosive, toxic and hazardous **Avoid contact with skin as it will burn!**
* Copper nitrate is a strong oxidizing agent and is toxic if ingested.
* Do NOT pour products down the drain Use a waste disposal container.

**Procedure:**

1. Clean copper wire and make it into a coil using a pencil
2. Place copper wire into the test tube, and ensure it sits at the bottom
3. Slowly pour 5 mL of silver nitrate into the test tube placed in a test tube rack. **Never hold a test tube in your hands when performing an experiment.**
4. Gently swirl the test tube and then wait 1-2 minutes.
5. Describe and record all observations.

**Reaction 2:**

**Materials:**

* mass balance
* scoopula
* test tube
* test tube tongs
* potassium permanganate (KMnO4)
* Bunsen burner & flint
* safety goggles
* splint

**SafetyPrecautions:**

* Avoid skin contact with potassium permanganate

**Procedure:**

1. Place approximately 0.5 grams of potassium permanganate into a clean, dry test tube**. Record all your observations.**
2. Using a metal test tube clamp heat the tube in the Bunsen burner flame, pointing the tube away from people.
3. While step 2 is being preformed, have your partner light a splint then blow out the flame, creating a glowing splint.
4. After you notice a change in the potassium permanganate remove the tube from the heat, turn off Bunsen burner and insert a **glowing splint\*** into the mouth of the test tube.
5. **Describe and record the results in your data table**.
6. Once the test tube cools, rinse the contents down the drain and record the colors produced by the dilution of the product. These colors indicate changes in the oxidation states.

**Reaction 3:**

**Materials:**

* Magnesium ribbon
* Bunsen Burner and flint
* tongs
* tile
* Safety goggles

**Safety Precautions:**

* Do NOT look directly at burning magnesium as it can cause eye damage.

**Procedure**:

1. Obtain a piece of Magnesium ribbon and hold one end with crucible tongs. Ignite the other end in a Bunsen burner flame.
2. After ignition, hold the burning magnesium over a tile until the reaction is complete.
3. **Do not look directly at the burning magnesium!**
4. Describe and identify the product.

**Reaction 4:**

**Materials:**

* 0.05 M Potassium iodide
* 1% Lead (II) nitrate
* Test tube
* 10mL graduated cylinder
* Safety goggles

**Safety Precautions:**

* Chemicals used are body tissue irritants. Wash hands with soap and water if exposed and at the end of the lab
* Lead (II) nitrate is moderately toxic and a possibly carcinogenic when ingested

**Procedure**:

1. Measure 5mL of potassium iodide using a graduated cylinder, pour into a test tube.
2. Add a few drops of lead (II) nitrate into the test tube.
3. Record all observations.
4. Dispose of waste in the **inorganic waste** bucket.

**Reaction 5:**

**Materials:**

* 1M Sodium chloride
* 1% Silver nitrate
* Test tube
* 10 mL graduated cylinder
* Safety goggles

**Safety Precautions:**

* Silver nitrate will burn the skin, avoid all contact

**Procedure**:

1. Place 5 mL of sodium chloride solution into a clean test tube.
2. Add 1 mL of silver nitrate solution. **Remember to clean graduated cylinders between measurements!**
3. Describe and record the results in the data table
4. Using the Solubility Rules from your textbook, determine the identity of the precipitate. Discard the products down the drain.

**Reaction 6:**

**Materials:**

* 1.0M Hydrochloric acid (HCl)
* 1 piece of Zinc
* Forceps
* Rubber stopper
* splint
* Safety goggles

**Safety Precautions:**

* Hydrochloric acid may cause eye, skin, and respiratory tract irritation.
* Zinc is a irritant if comes in contact with skin, wash area with soap

**Procedure**:

1. Place 5 mL of 1.0M hydrochloric acid into a clean test tube that is positioned in the test tube rack. (Remember experiments are **never** performed in a graduated cylinder.)
2. To the acid in the test tube, add a piece of zinc. (The zinc should be handled with forceps rather than with fingers.)
3. Cover tube with rubber stopper. After the tube stops bubbling, remove stopper and place a **flaming splint** into the mouth of the test tube. Describe and record the results in the data table.
4. For disposal, fill the test tube with water and flush the **solution** down the drain. Discard the remaining **solid** in the inorganic waste receptacle provided.

**Data Chart: (13 marks)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Reaction** | **Properties of Reactants**  **(Before Reaction )** | **Observations During Reaction** | **Properties of Products**  **(After Reaction)** | **Splint Test Result** | **Type of Reaction** |
| **1** |  |  |  |  |  |
| **2** |  |  |  |  |  |
| **3** |  |  |  |  |  |
| **4** |  |  |  |  |  |
| **5** |  |  |  |  |  |
| **6** |  |  |  |  |  |

**Discussion Questions: (27 marks)**

1. Write a balanced equation for all of the reactions preformed and name what type of chemical reaction occurred. (18 marks)
2. What element or compound is responsible for the colour of the solution after Reaction 1 has occurred? (1 mark)
3. Name a product of Reaction 2 and describe how it was identified? (1 marks)
4. Magnesium ribbon is sometimes used as a fire starter when camping. What would be produced if it rained after the magnesium was burned? What type of chemical reaction is this? (1 marks)
5. The precipitate formed in Reaction 4 is often used in paint; suggest a possible method that one could use to separate the products. (1 mark)
6. What would happen if you didn’t clean the graduated cylinder while measuring the two reactants in reaction 5? (1 mark)
7. Why is it not a good idea to clean your metal countertops with an acid such as hydrochloric acid? (1 mark)